Surface Water and Groundwater Relationships in Nebraska

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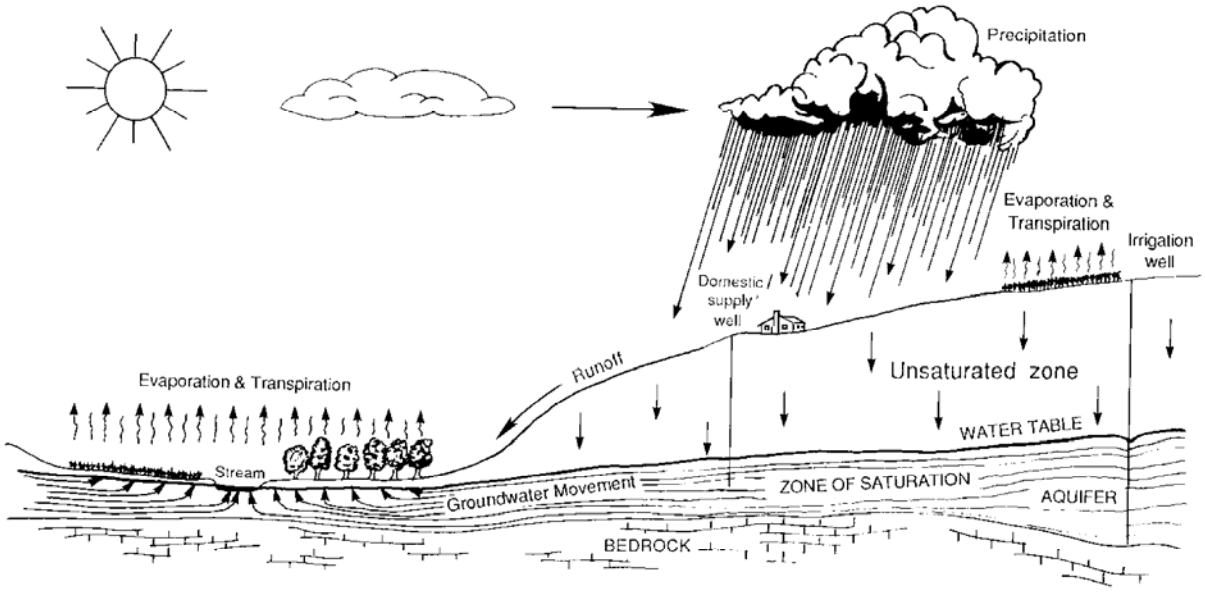
For years in Nebraska the connection between ground water and surface water has been poorly understood and as a result a contentious issue. The nature of the resources makes this understandable. Surface water is readily accessible to use, measure, and comprehend. Ground water is much less accessible and more difficult to use, measure, and comprehend. The reality is *surface water and ground water are intimately connected* and this understanding is essential for the future of water use and development in Nebraska.

Figure 1 illustrates in cross-section how the connection between ground water and surface water is part of the water cycle in Nebraska. When there is precipitation on Nebraska it can run off to streams, evaporate back to the atmosphere, be incorporated by vegetation and transpired back to the atmosphere, or move below the root zone and move downward through the **unsaturated zone** to a point where all pore spaces in the sediments are full of water. This point is the top of the saturated zone or **water table**. All sediments below the water table are considered to be saturated.

Figure 1.



The unsaturated zone in Nebraska may be anywhere from a few feet to over 300 feet. The thickness of and types of sediments in the unsaturated zone determine how long it takes **recharge** from precipitation to reach our ground water reservoirs. This is of vital importance because recharge from precipitation is the source of most of our ground water in Nebraska. Depending on local conditions it might take days, months, or years for recharge to reach the water table.

The water table is often a subtle reflection of the land surface. Just as the land surface slopes, so does the water table. This slope, or gradient, on average in Nebraska is about 10 feet per mile, or almost a flat line, so there is little driving force to move water through the very small, poorly connected pore spaces in the saturated silts, sands, and gravels that comprise Nebraska aquifers.

Groundwater Movement

While surface water moving through open stream channels is measured in feet per second, *ground water flow is calculated in feet per year*. Average rates of ground water flow in Nebraska are less than 300 feet per year. The long lines in the zone of saturation in Figure 1 are flow lines indicating ground water flowing from higher to lower elevations with eventual discharge to streams. Considering the very slow movement of ground water, it might easily take ground water hundreds of years after being recharged to become surface water.

Below the zone of saturation are impermeable bedrock units. The top of this bedrock surface is the base of the aquifer. The difference between this surface and the water table is referred to as the **saturated thickness**. In Nebraska saturated thicknesses vary from just a few feet to over a thousand feet in the heart of the Sandhills. While saturated thickness is important, it is essential to know what kind of materials comprise the saturated thickness because coarser materials like sands and gravels will provide more water more easily to wells.

It is reasonable to think of the ground water reservoir as a massive inexorably moving conveyor belt transferring ground water to points where it intersects with the land surface and becomes surface water. When we tap into the conveyor belt with wells and remove water for irrigation, the amount of water consumptively used (not to return to the conveyor belt) diminishes the water that will eventually be delivered to a stream. Because of the very slow rate of ground water movement, this diminished flow may not be realized for years, decades, or centuries. This "**lag time**:" is cause for us to consider our water use today in order to account for the impacts of our water use today well into the future.

Nebraska's Connected Water Resources

It is ironic that as the home of "The Great American Desert", Nebraska is blessed with abundant connected surface and ground water resources. On the average since 1950, 1.7 million acre feet of water flow into Nebraska and 8.9 million acre feet flow out. It has been estimated that ground water makes up to 10 to 20% of the flow of the Big Blue, Little Blue, and Republican Rivers and 50 to 90% of the flow of the Platte, Loups, Elkhorn, and Niobrara. The difference in contribution is a reflection of more overland runoff from the fine textured soils in the Blue and Republican drainages and less overland runoff and much more ground water contributions from the coarse textured sandy soils of the Platte, Loup, Elkhorn, and Niobrara drainages.

While it may be difficult to consider how much of the flow of the Platte comes from ground water, the connection is much easier to understand where the water table intersects the land surface and streams begin to flow. The headwaters of streams like Whitetail Creek, Blue Creek, Birdwood Creek, Red Willow Creek, Medicine Creek, and Frenchman Creek are outcrops of water

representing the points of connection where ground water becomes surface water. As the water rises and falls in response to seasonal stresses these points of connection may move miles.

The ground water reservoir that contributes so substantially to Nebraska's streams is huge. USGA hydrogeologists in 1980 estimated the total recoverable ground water in the eight High Plains Aquifer states at 3.25 billion acre-feet. Nebraska's portion was estimated at 66% of the total or 2.145 billion acre-feet.

By 1980 the ground water depletion across the eight High Plains Aquifer States was estimated at 166 million acre-feet, with 70% of the total being in Texas. Because areas of ground water rise in Nebraska offset areas of decline, Nebraska with 66% of the available water in storage had 0% of the declines.

Even with continued irrigation development in Nebraska, by 2003 the total available ground water in Nebraska had only been reduced or depleted by 11.4 million acre-feet. The reduction or depletion, while it may seem considerable, is only 0.53% of the total available ground water supply in Nebraska, just a bit over ½ of 1%.

So what's the big deal? First, the declines are unevenly distributed and while only a small percentage of the whole they represent water level declines of 40 to 50 feet in Upper Republican NRD, the Upper Niobrara White NRD (Box Butte County) and the Big Blue River Basin.

Second, even a seemingly small reduction in the total available ground water supply can have a negative impact on stream flows. Again, referring back to the massive inexorably moving conveyor belt as our ground water reservoir, it may be many years before the impact of concentrated consumptive use from irrigation today is realized in decreased future streamflows.

Unaffected by the activities of man, surface water flows and ground water levels vary according to long term wet and dry cycles. We refer to this balance as predevelopment condition. Surface water use for irrigation began in Nebraska in the 1860's while the technology to develop Nebraska's ground water reservoirs came almost 100 years later.

Nebraska's Water Law

The Doctrine of Prior Appropriation (first in time, first in right) was proposed for the regulation of surface water in the late 1880's and put into practice with the formation of the Department of Water Resources in 1895, probably driven by the drought of 1892-1893.

Ground water management legislation came 80 years later when the Ground Water Management Act was passed in 1975. Ground water is managed under the concept of *Correlative Rights* where everyone has the right to beneficial use of the ground water underlying their land and in times of shortage share and share alike. The Ground Water Management Act assigned to the Natural Resource District, established in 1972, the responsibility of locally administering the Act.

For 21 years Nebraska had two parallel legal management systems for a connected resource. The passage of LB108 in 1996 recognized *conjunctive use* and the *connection of surface water and ground water*. The passage of LB 962 in 2004 acknowledged the connection between surface water and ground water and provided for the effective management of Nebraska's hydrologically connected surface and ground water through the designation of over appropriated and fully appropriated areas as originally designated by the *Cooperative Hydrology Study* (**COHYST**) ground water model.

Groundwater Models

In 1997 Nebraska joined Colorado and Wyoming in the Cooperative Agreement to manage the flow of the Platte Rivers system. Under this agreement the COHYST was undertaken to develop a model of the Platte basin in Nebraska from Columbus to the Nebraska-Wyoming state line. The model was divided into eastern, central and western units. The geology was characterized by 10 hydrostratigraphic units. The model grid size was a quarter section or 160 acres. The model was used to establish stream depletion factor lines, or SDF lines, which encompass and define the over appropriated and fully appropriated areas.

Based on earlier modeling, the *28-40 line* was designated as the line defining the over-appropriated area. 28-40 refers to a line defining an area within which pumping a well for 40 years would directly or indirectly affect baseflow to a stream by 28% or more of what the well pumped over the 40 year period. Over-appropriated indicates that 28% is a significant impact and 40 years is a relatively short period in which to realize such an impact.

The COHYST model was also used to designate as fully appropriated the areas defined by the *10-50 line*. 10-50 refers to a line defining an area within which pumping a well for 50 years would directly or indirectly affect baseflow to a stream by 10% or more of what the well pumped over the 50 year period. In areas outside of the COHYST model, over appropriated and fully appropriated determinations were based on the best available data and used the Jenkson method to determine the 28-40 and 10-50 lines. Modeling efforts similar to COHYST are being initiated to standardize the definitions for over appropriated and fully appropriated areas of the areas of Nebraska outside of the COHYST area.

We are at a unique point in Nebraska history, similar to the late 1880's when the installation of windmills and use of barbed wire closed the open range. Instead we are closing easy access to ground water and connected surface water. Our drought since 2000 will ease off, but our interstate agreements and legislation will mandate a higher awareness of our water resources and maximum efficiency of use to maintain some measure of sustainability of our water resources.